Observations on the Taxonomic Characters of *Triops orientalis* (Tiwari), with a note on its Biology

BY

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(*With a plate*)

INTRODUCTION

The genus *Triops* Schrank belongs to the order Notostraca of Euphyllopod Crustacea with shield-shaped carapace. Keilhack (1909), Fox (1949), and Longhurst (1955) have suggested that the generic name *Apus* Schaeffer, 1765, should be rejected in favour of *Triops* Schrank, 1803. This practice will avoid further confusion of this genus with the equally well-known avian genus *Apus* Scopoli, 1777. We therefore propose to follow the above-mentioned authors in the use of the generic name *Triops*.

The great rarity of *Triops* and other branchiopods makes this group of special interest to zoologists all over the world. In India, *Triops* has been recorded from only a few places. The present work deals with *Triops orientalis* (Tiwari) specimens of which were collected from the waterpools at Panchgani, N. Satara (W. India), during the months of July to November 1956.

The taxonomy of the Notostraca has been based entirely on characters of the setae and spines which comprise the armature of the exoskeleton, and on the various body proportions. The validity of these characters have been discussed by Barnard (1929), Gauthier (1933), Linder (1952), and Longhurst (1955). Various characters of taxonomic importance suggested by these workers have been studied here separately. In addition, observations are also made on the feeding habits and the sex-ratio with a view to re-examine the findings of Gurney (1925), Fox (1949), and Tiwari (1951).

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Colour

The adult body colour in *T. orientalis* is useful in distinguishing the sexes both in the fresh and the formalin preserved material. While juveniles of both sexes are more or less alike in body colour, Gurney (1925) has rightly described the adult females as deep green, the males being paler and tending more towards a brownish tinge. However, in the material we have studied, we find that the males are yellowish red rather than brownish in colour.

The colour is due to the presence of two pigments within the body and the brown pigment in the exoskeleton (Longhurst, 1955). It is also observed that in a number of specimens, particularly in females, a coating of green algae gives an added green colour to the body.

A dark blue-green pigment is generally more abundant in *Lepidurus* which is the only other genus in the order Notostraca. This may be completely absent in some species of *Triops*, but in *T. orientalis*, however, this pigment is present particularly at the basal ends of the thoracic limbs, the edges of the labrum, and the anterior ventral edge of the head. It is abundant in well-grown and healthy forms as was noted by Longhurst (1955). Fox (1945) attributed the intensity of red coloration to haemoglobin depending upon the oxygen content in the surrounding water, varying inversely with the O_2 content.

Our observations indicate that the forms that are bright red are full grown and healthy. The exoskeleton in such animals is also strong in contrast to those showing pale yellowish colour. The red coloured forms are more abundant when the conditions of the pond are more favourable, while the yellowish red forms are more abundant when the season is almost at the end and the ponds begin to dry. It would therefore appear that the difference in coloration need not necessarily be due to poor O_2 content in the surrounding water, but could be a sign of good health of the animal.

Size

Under normal conditions males and females do not show any significant difference in size. The growth rate depends upon various conditions, as was seen in animals kept under laboratory observation. Table I shows the percentage of different size groups collected at various times during the season. It will be seen from this table that the group measuring 2 cm. to 3.9 cm. is predominant and could be taken to represent the average size of the adult form.

TABLE I

showing the percentage of different size groups in a total collection made in one complete season in 1956

Size group	*Percentage*
0 cm. to 0.9 cm.	0.66%
0.9 cm. to 1.9 cm.	22%
1.9 cm. to 2.9 cm.	36.94%
2.9 cm. to 3.9 cm.	35.86%
3.9 cm. to 4.6 cm.	4.44%

CARAPACE (Fig. 1)

The size and shape of the carapace are usually considered as important taxonomic characters (Ghigi, 1921, and Tiwari, 1951), while Linder (1952) attaches little importance to these. The differences in these characters in both males and females of *T. orientalis* are not significant enough to consider them as taxonomically important.

The validity of length/width relationship of the carapace as a taxonomic character has been studied in some South African species of *Triops*. In *T. orientalis* the length and the width of the carapace is practically the same. This may be characteristic for the species.

The carinal spines (*cs*) on the carapace which are not arranged in a straight line but show various patterns are short, blunt processes, the numbers of which vary from 1 to 6. The majority of individuals have 3 or 4.

Longhurst (1955) suggests that there is a loose correlation between the occurrence of the terminal spines (*ts*) and other characters. In *T. orientalis* the only correlation that we find is between the terminal spine and the body-length. In the long-bodied forms it is usually absent but when present it is much reduced, while in short-bodied forms it is well developed.

The sulcal spines (*ss*) on the posterior emargination of the carapace show considerable variation between individuals. For this reason, Barnard (1929) and Longhurst (1955) reject its use as a taxonomic character. We find that the number of sulcal spines ranges from 42 to 71, the majority showing between 50 and 60 spines. It would appear that the minimum number of 42 spines agrees well with the condition observed by Tiwari (1952) and may be taken to represent a character of taxonomic significance. The maximum number of the spines is, however, variable.

BODY SEGMENTS

T. orientalis resembles many other species of this genus in being not nomomeristic. Both the leg-bearing segments and the apodal

segments show variations in number and are combined in different ways, so as to give a total number varying from 35 to 40. No correlation was found to exist between the total number of segments and the body length (Table II).

TABLE II

showing the body length, carapace length, and the body segment relationship

Length of animal	*Length of carapace*	*Total no. of segments*
4.4 cm.	1.8 cm.	39
4.1 cm.	1.8 cm.	38
3.9 cm.	1.7 cm.	38
3.9 cm.	1.3 cm.	38
3.8 cm.	1.6 cm.	39
3.7 cm.	1.7 cm.	38
3.4 cm.	1.4 cm.	39
3.4 cm.	1.4 cm.	38
3.3 cm.	1.5 cm.	39
3.3 cm.	1.6 cm.	38
3.2 cm.	1.4 cm.	35
3.2 cm.	1.5 cm.	39
3.1 cm.	1.4 cm.	38
3.1 cm.	1.6 cm.	40
3.0 cm.	1.5 cm.	38
2.9 cm.	1.3 cm.	38
2.8 cm.	1.3 cm.	36
2.5 cm.	1.4 cm.	38

TABLE III

A. Males

Size of animal	*Leg-bearing segments*	*No. of legs*	*Place of 30th pair of legs*
4.9 cm.	26	51	8
3.7 cm.	26	50	9
3.6 cm.	26	48	9
3.6 cm.	26	50	8
3.4 cm.	25	45	10
3.3 cm.	26	53	10
3.3 cm.	25	47	—
3.2 cm.	25	48	8
3.1 cm.	26	47	10
3.1 cm.	24	49	8
3.0 cm.	25	47	8
3.0 cm.	26	53	9
2.8 cm.	26	52	7
2.7 cm.	24	49	10
2.6 cm.	27	49	10
2.4 cm.	26	48	9
2.2 cm.	26	46	10
2.2 cm.	26	52	9
2.1 cm.	26	52	9

B. Females

Size of animal	*Leg-bearing segments*	*No. of legs*	*Place of 30th pair of legs*
3.4 cm.	28	53	7
3.4 cm.	28	55	9
3.3 cm.	26	51	9
3.0 cm.	27	51	—
3.0 cm.	28	57	7
2.8 cm.	28	51	9
2.5 cm.	28	55	7
2.5 cm.	27	58	7
2.5 cm.	26	54	—
2.2 cm.	—	—	—
2.4 cm.	27	53	8
2.4 cm.	28	55	9
2.4 cm.	27	50	—
2.4 cm.	26	50	8
2.4 cm.	27	54	9
2.3 cm.	28	51	7
2.2 cm.	27	52	8
2.2 cm.	28	51	7

Pedal segments (Table III A, B)

In *T. orientalis*, the number of leg-bearing segments ranges from 24 and 28. Usually, the females have more leg-bearing segments, varying between 26 and 28, while in the males they are 24 to 27. The high number of leg-bearing segments is correlated with a corresponding higher number of body segments, especially in females.

Exposed segments

There is a great variation in the number of exposed segments, which ranges between 15 and 27. However, in the majority of forms the number recorded is 21 to 23. Generally, in the forms measuring above 3 cm. the range of exposed segments is 23 to 27 and in those measuring below 3 cm. the range is 19 to 26. Being so highly variable, the exposed segments are not considered as of taxonomic importance.

Limbs

In *T. orientalis*, the number of legs also varies between 45 and 58 and as shown in the Table (III A, B) their number is more in females than in males. Linder (1952) has noted this phenomenon in certain N. American species of *Triops*. As will be seen from the table there appears to be no relation between the number of legs and the body length. A pair of legs, except perhaps the first few pairs, has no definite position on the segment either in the male or the female. Table III clearly shows the place of the 30th pair of legs on the body segments.

Telson (Fig. 2)

Longhurst (1955) observes that *Triops* from different regions show a strong correlation between the geographical distribution and the spine pattern of the telson. A study of the armature of the telson in *T. orientalis* reveals that this species may be related to those of *Triops* found in Europe, W. Russia, N. Africa, the Middle East, and N. India. All these forms, according to Longhurst (1955), show a small number of median spines (*ms*) arranged in a row in the centre of the telson. The furcal spines (*fs*) are few and large, while the posterior marginals (*pms*) are small and thin.

In *T. orientalis*, the pattern of the spines on the telson remains constant unlike most of the non-Indian species of *Triops*. The number of the median spines varies from 0 to 6, but generally it is 2 or 3 irrespective of size or sex (Table IV).

Table IV

showing variations in the no. of median spines in 135 specimens examined.

No. of median spines ..	0	1	2	3	4	5	6
Number of occurrences ..	1	10	39	57	19	6	3

The furcal spines are well developed and number 5 to 7. The setal spines (*sts*) do not show much variation in their pattern but their number varies from 2 to 6. The number of dorsal spines vary with the size of the individual. As many as 150 spines were counted in a specimen measuring 3.8 cm.

Second Antenna

It is of special interest to note that the second antenna is present in this particular Indian species. It is a small hook-like structure on the sub-frontal plate.

Habits

Triops inhabit temporary water pools, which are formed during the monsoon and are available from about the beginning of July to the middle of November, when the Tableland at Panchgani is covered with a large number of ponds of varying sizes. These temporary waterpools are at the most knee-deep, and therefore it is very easy to catch *Triops* and allied forms without the help of nets. These animals lay resting eggs which are able to withstand desiccation for considerable periods and may be collected during the dry season.

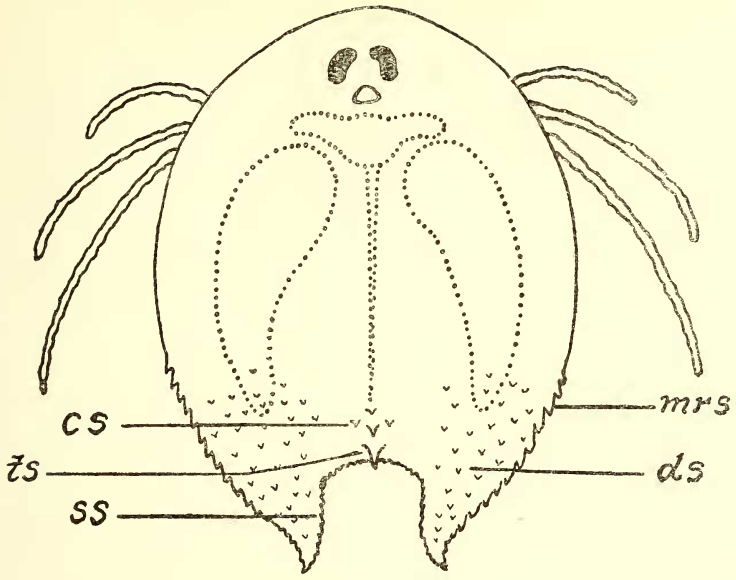

FIG. 1

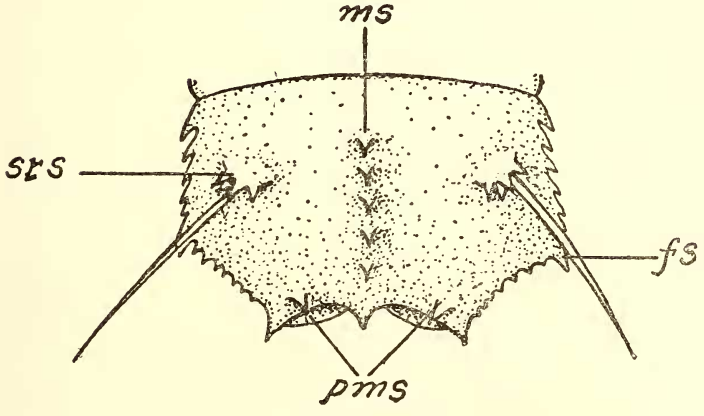

FIG. 2

Triops orientalis

Fig. 1. Carapace : *ds* dorsal spines; *ts* terminal spine; *cs* carinal spines; *ss* sulcal spines; *mrs* marginal spines.

Fig. 2. Telson : *ms* median spines; *sts* setal spines; *pms* posterior marginal spines; *fs* furcal spines. (Enlarged).

It has been observed that *Triops* feed on bacteria, protozoa, *Daphnia*, Copepoda, small oligochaetes, and also on *Streptocephalus*, and Leptestheriied forms. However, they find it difficult to eat forms like *Estheria* as the latter are covered with hard bivalve shells. Usually, it catches hold of its prey and with powerful pairs of mandibles and the first maxillary blades tears off the carapace and eats the soft parts of the body. This has been confirmed by the examination of the alimentary canals, where a large amount of semi-digested food is present. Particularly, parts like the second antenna, limbs, and the telson of *Estheria* are of common occurrence, together with shells of *Daphnia* and different hard parts of its own kind.

Triops exhibit cannibalism and it is interesting to note that even a small individual can easily eat a bigger one. It catches its prey from the dorsal side, just posterior to the carapace. It divides its prey into two parts with the powerful mandibles, and eats up everything except the carapace, mandibles, and certain other hard parts of the body. It is also observed that a number of *Triops* together attack one individual and eat it completely.

Triops is recorded as a pest of rice cultivation in different parts of the world such as Kashmir (Walton & Kemp, 1911), Spain (Font de Mora, 1923), Italy (Tassinari, 1941), and California (Rosenberg, 1946). Fox (1949) observes that *Triops* are not harmful to the plants as they do not feed on them. However, we have observed *T. orientalis* eating the blades of grasses which it bites vigorously by means of the maxillae and the mandibles. This observation is supported by laboratory feeding and the examination of a large number of alimentary canals which showed numerous fragments of grasses.

A female *Triops* starts laying eggs when it reaches 1.5 cm. in length. The number of eggs laid by a single individual at a time ranges from 5 to 20. The egg-laying capacity increases with the age of the female. The eggs in the oostegopod are red in colour, but when liberated outside the body the colour becomes pale. These eggs remain stuck to the blades of grasses, and when the ponds dry up a large number of eggs are seen buried in the superficial layers of the soil.

The genus is well known for its discontinuous distribution. A number of favourable factors help in the thriving of *T. orientalis* in the rainwater pools on the Tableland at Panchgani. Here they appear to have no enemies except frogs and nematode worms, the latter being found as external parasites on the carapace. The rainwater pools being temporary, the eggs are adapted to withstand desiccation for considerably long periods. A large amount of food

is also available in the form of estherids, copepods, *Streptocephalus*, and *Daphnia*, all of which are found here in great abundance.

Sex-ratio

With a view to re-examine the findings of Tiwari (1951) and Gurney (1911) on the sex-ratio in *T. orientalis*, more than a thousand specimens were carefully studied. As many as thirteen trips were made to Panchagani, from the middle of June to the middle of November 1956. The collected material was placed in different size groups and the sex-ratio studied group-wise for every month of the season (Table V).

In June, with the onset of the monsoon, a number of them develop from the resting eggs, the females outnumber the males, the former constituting 65.4% and the latter 34.6% of the total catch.

In July, the sex-ratio in general does not show much variation in almost all the size groups.

In August, during the middle of the season, the females are still more numerous (females 53%; males 47%). The dominance of females over males is particularly noticeable in specimens measuring below 3 cm. while in the larger forms the males outnumber the females.

In September, in almost all the length-groups, females are more than males and constitute 67% of the total collection. The variations in the sex-ratio in all the size-groups are not very large, except in the 2 to 2.9 cm. group. This is the dominant size group in September and the females here outnumber the males by a large margin showing a ratio of 4:1.

The same condition was observed in October when out of 368 specimens collected, 62% were found to be females and 38% males. Group-wise analysis also revealed that in all size-groups females outnumber males by a considerable margin.

In November, at the end of the season, forms belonging to the late generation are found. Here, also, females predominate in numbers and in some samples the occurrence of males is quite negligible. Of the total collection made for the month, 84% are females (5:1) and in the 1.0 to 1.9 cm. group the female-male ratio is 13:1.

Males are generally known to be rare in Genus *Triops*. According to Gurney (1911) *T. orientalis* (=*Apus asiaticus*) males outnumber females. Tiwari (1951) also arrived at the same conclusion after examining collections from Panchagani but observed that 'as the samples do not appear to be random no statistical inference can be derived from them beyond the fact that males are quite abundant in this species'.

TABLE V

Sex-ratio in *Triops orientalis*
YEAR 1956

Size Group	June		July		August		September		October		November	
	Female	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*
0 cm.—0.9 cm. ..	—	11.5	—	—	—	—	1	—	—	—	—	—
1 cm.—1.9 cm. ..	65.4	23.1	26.5	26.5	16.5	2.5	12.5	9.5	6	3	52	4
2 cm.—2.9 cm. ..	—	—	22.5	24.5	22.5	12.5	36.5	8.5	22	9	32	12
3 cm.—3.9 cm. ..	—	—	—	1	10.5	26.5	15.5	13.5	31.5	24.5	—	—
4 cm.—4.9 cm. ..	—	—	—	—	3.5	5.5	1.5	1.5	2.5	1.5	—	—
	65.4	34.6	49	51	53	47	67	33	62	38	84	16

Figures given represent percentages.